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GROWING POTATOES IN CALIFORNIA

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THE SEED YOU PLANT

is the most important factor in potato production. No matter how good your general cultural practices are, high yields and good quality can be expected only if certified disease-free seed is planted.

THIS CIRCULAR, written for the farmer who is just going into potato growing, devotes special attention to potato seed, its certification, dormancy, and methods of seed treatment. It also discusses proper soil conditions, suitable varieties, and gives step-by-step methods for potato culture, from preparing the land to harvesting the crop.

About 120,000 acres are planted to potatoes in California. Average yields in this state are high, and California-grown potatoes are available during the entire year. To maintain this high production, the soil must be kept free of diseases and nematodes. This requires planting new land and rotating crops. Cultural practices which keep the soil clean, as well as chemical methods for controlling pests and diseases of the potato, are included in this circular.

For: **See Page:**

WARNING

The organic phosphates (parathion, hexaethyl tetraphosphate and tetraethyl pyrophosphate) are exceedingly dangerous to human beings in extremely minute amounts when ingested, inhaled or absorbed through the skin. The precautionary statements contained in this publication concerning these materials may not be wholly adequate.

Growing Potatoes in California

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THE POTATO is generally thought to thrive best in regions having a relatively cool growing season. However, high yields per acre are produced in some of the interior valleys of the state where the air temperature during part of the growing season is relatively high.

Potatoes are grown in thirty-seven of the 58 counties in California. There is a tendency for the greater volume of production to be concentrated in a relatively few counties where the environmental conditions are most favorable. The early crop, harvested in May and June, is limited to approximately eighteen counties as shown in table 2 while the late crop, harvested in October and later, is produced in all thirty-seven counties (table 1).

Producing Areas

About ninety per cent of the total state acreage is located in four principal districts comprised of eleven counties.

Upper San Joaquin Valley. This area, consisting of Kern, Tulare, Madera, Fresno and Merced counties, listed in order of importance, is the largest production area in the state with a total of 82,000 acres planted to potatoes in 1946. The sandy soils and warm spring weather are favorable for the growing of standard varieties for early shipment. Plantings are made from late November to March, the crop maturing in May and June. White Rose is the chief variety grown, with limited acreages of Calrose, Triumph, and Pontiac.

Riverside–San Bernardino. In this area most of the acreage is planted in the vicinity of Chino, Colton and San Bernardino in San Bernardino County, and near Temecula, Elsinore, Perris, Moreno and Riverside in Riverside County. White Rose is the main variety. The greater part of the acreage is planted in the winter and early spring for market, while most of the smaller late crop, planted in July and August, is grown for seed.

Tulelake District. The Tulelake district is composed of portions of Siskiyou and Modoc counties. White Rose and Russet Burbank are the main varieties grown. Most of the crop in this area is planted in May and harvested in October, and stored for shipment during the winter and spring. Although subject to a very short growing season, high yields are obtained.

Delta District. In 1946 there were 6,500 acres planted to potatoes in the Delta district, which includes San Joaquin and Contra Costa counties. Potato soil in this area consists largely of reclaimed peat land. Most of the acreage is planted in April to June to the late crop, a goodly portion of which is used for seed. Proper fertilization has made high yields possible.

Other Areas. Other smaller districts in the state include the Santa Maria Valley in Santa Barbara County; San Diego County; Los Angeles County; Butte County; Humboldt County; Modoc, Lassen and Inyo counties on the east side of the Sierras; the Colma district south of San Francisco; and the Alvarado district in Alameda County.

California's Potato Acreage

Table 1. CALIFORNIA LATE POTATO ACREAGE BY COUNTIES. 1943–1948

County	Year					
	1943	1944	1945	1946	1947	1948 (Preliminary)
Alameda	200	300	300	200	200	200
Butte	200	200	200	200	400	400
Contra Costa	1,000	800	1,000	900	700	1,000
Del Norte	100	100	100	100	100	100
Fresno	400	500	900	600	500	500
Humboldt	800	800	800	600	600	500
Inyo	800	300	300	300	300	300
Kern	3,700	3,700	5,700	3,800	4,000	4,300
Kings	300	300	.....	.....	.....	.....
Lassen	300	100	100	100	100	100
Los Angeles	1,000	500	900	800	600	1,000
Madera	1,800	1,500	1,000	800	800	800
Marin	300	300	300	200	200	200
Mendocino	300	200	300	300	300	300
Merced	300	100	100	100	.....	.....
Modoc	5,700	6,000	5,000	4,500	3,300	4,000
Mono	100	100	100	100	100	100
Monterey	600	300	400	400	200	300
Orange	200	200	200	200	100	100
Plumas	100	100	100	100	100	100
Riverside	1,400	1,600	3,300	1,500	2,500	2,500
Sacramento	100	100	100	100	.....	.....
San Benito	800	700	800	800	900	1,000
San Bernardino	100	100	300	600	600	800
San Diego	100	.....	....	.....	.....	.....
San Joaquin	8,000	8,600	7,500	5,500	6,300	7,200
San Luis Obispo	300	300	400	400	2,400	3,500
San Mateo	400	300	300	300	100	100
Santa Barbara	3,800	2,400	3,600	4,500	2,200	3,500
Santa Clara	100	100	200	100	100	100
Santa Cruz	100	100	100	100	100	100
Shasta	300	200	200	100	100	100
Siskiyou	4,800	4,700	6,000	5,900	2,100	2,000
Sonoma	800	900	600	500	600	500
Stanislaus	100	100	100	100	100	100
Tehama	100	100	100	100	100	100
Trinity	100	100	100	100	100	100
Tulare	1,400	2,200	4,500	5,000	3,100	4,000
Total	41,000	39,000	46,000	40,000	34,000	40,000

Table 2. CALIFORNIA EARLY POTATO ACREAGE BY COUNTIES. 1943–1948

County	Year					
	1943	1944	1945	1946	1947	1948 (Preliminary)
Alameda	200	150	100	100	100	.....
Fresno	900	1,500	2,200	1,500	500	800
Kern	36,700	50,300	55,100	61,600	47,000	60,400
Los Angeles	800	600	900	600	600	200
Madera	700	1,500	2,000	2,500	2,400	2,100
Merced	500	700	500	100	100	50
Monterey	100	100	100	100	.....	.....
Orange	100	100	100	100	100	50
Riverside	2,800	3,000	3,800	4,200	2,700	5,500
Sacramento	50	.....	.....	.....	.....	.....
San Bernardino	1,800	1,800	2,000	2,300	1,500	2,400
San Diego	400	300	200	300	100	200
San Joaquin	600	500	500	100	.....	.....
San Mateo	250	250	300	200	200	100
Santa Barbara	.....	.....	.....	100	100	200
Santa Clara	200	100	100	100	.....	.....
Santa Cruz	100	100	100	100	.....	.....
Tulare	2,800	3,000	5,000	7,000	6,600	8,000
Total	49,000	64,000	73,000	81,000	62,000	80,000

Varieties that Do Best in California

Only a few distinct varieties of potatoes are grown in California, although a confusing array of names is applied to them. The generally accepted proper name is used in the brief discussion of varietal characteristics which follows. The ability to identify the different varieties is important if for no other reason than the prevention of varietal mixtures in seed. (See pages 6 and 7.)

White Rose. Synonyms: American Giant, Wisconsin Pride, Late Pride, Long White, Delta White, Shafter White.

White Rose is the main variety of potato grown in California. It is thought to be a selection from Wisconsin Pride by H. L. Musser. It is a medium-early variety, earlier than Russet Burbank, but later than Triumph. The tubers are large, long, somewhat flattened, usually irregular, skin smooth and white, eyes numerous, medium in depth and the flesh is white. The rest period is short, a characteristic that makes the variety well adapted to growing two crops a year.

Calrose. The variety Calrose was originated by the United States Department of Agriculture from a cross between the varieties Ackersegen and Katahdin. Calrose is a high-yielding variety that has proved to be well adapted to environmental conditions in California. The plants are large, spreading and bright green. The flowers are pale lilac with white tips. Tubers are large, regular in outline, elongated; the skin is smooth, tough, dark cream-buff; and the eyes are shallow. The flesh is white with a slight yellow tinge.

Learn to Identify the Vines and Tubers

Table 3. SOME CHARACTERISTICS OF THE POTATO VARIETIES MOST WIDELY GROWN IN CALIFORNIA

Variety	Vines	Tubers			Flowers	Relative maturity
		Type	Color	Skin		
White Rose	Erect, spreading, bright green	Long, flattened in cross section, eyes few	White	Smooth	White	Intermediate
Calrose	Large, spreading, bright green	Long, eyes few	Dark cream-buff	Smooth	Pale blue, white tips	Late
Russet Burbank	Medium to large, spreading, dark green	Long, eyes numerous	Dark cream-buff	Russeted	White	Late
Pontiac	Large, spreading dark green	Large oblong to round	Red	Smooth	Reddish purple, white tips	Late
Triumph	Large, spreading, nodes slightly reddish purple	Large to medium round, thick	Red	Smooth	Pink	Early

PONTIAC **TRIUMPH**

RUSSET BURBANK **WHITE ROSE** **CALROSE**

Calrose possesses sufficient resistance to late blight to protect it against mild attacks of the disease. It is quite tolerant to high air temperature and requires a relatively long period of growth, which should enable it to supplement other varieties in extending the length of the harvesting and marketing period in districts where such procedure is desirable.

Russet Burbank. Synonyms: Netted Gem, Idaho Russet, California Russet, Golden Russet.

The Russet Burbank, origin unknown, is a late-maturing variety grown to some extent in the Tulelake district, at Santa Maria, and at the higher elevations in the Sierras. The plants are medium to large, spreading. The flowers are white. Tubers are large and long, regular in shape, skin russeted, heavily netted. The eyes are numerous, well distributed and shallow. The flesh is white. There is a tendency for this variety to produce tubers with knobby second growth when grown on heavy soil or with an irregular moisture supply.

Triumph. Synonyms: Bliss, Bliss Triumph, Red Bliss, Coconino Red, Hawaiian Rose, Stray Beauty.

Triumph originated in Connecticut and was introduced by B. K. Bliss and Sons in 1878. It is thought to be the result of a cross between Peerless and Early Rose. This variety is grown in Butte County, in the Colma district, and to a limited extent in Kern County. It is of early maturity. Plants are large to medium spreading; stems thick with nodes slightly swollen and somewhat reddish purple in color. The flowers are phlox pink with orange-yellow anthers. Tubers are large to medium, round, thick; skin smooth, red; eyes medium in depth; flesh white.

Pontiac. Pontiac was developed by the United States Department of Agriculture from a cross between Triumph and Katahdin. The plants are large, spreading, stems thick, dark green. The flowers are light reddish purple with tips nearly white. Tubers are large, oblong to round, blunt at ends, skin smooth or sometimes slightly netted, red; eyes medium in depth; flesh white. Pontiac is a high-yielding late variety of value where red varieties are in demand. It is especially adapted to peat soils.

Temperature and Soil Requirements

In general, relatively cool conditions (60° to 75° F) are considered most favorable for plant and tuber development. Potato culture is most successful in the northern tier of states, but good crops of early varieties are grown in the south in the spring and fall. California growers have demonstrated that under proper cultural practices exceptionally high yields may be obtained in certain districts of California where the summer daytime temperatures frequently exceed 100° F.

Under high temperature conditions the soil temperature is kept relatively low either by frequent irrigation on the sand and silt types, or by the continuous subirrigation practiced in the peat districts where the water level is held 18 to 24 inches from the soil surface until the crop approaches maturity. Almost complete absence of leaf spot fungus diseases where the temperature is so high doubtless contributes to high yield.

The potato is probably as cosmopolitan in regard to soil requirements as any of our agricultural food crops, but like any other crop it thrives best on certain types of soil. The most favorable soils for potatoes are fertile, well drained and of rather loose texture. High fertility and the application of adequate fertilizer are necessary for maximum yields. In California potatoes are usually grown in sandy loam, silt loam, or peat soil types. Poorly drained soils, soils with an impervious subsoil and little depth of surface soil, or heavier types such as clay,

should always be avoided. Tubers grown under such conditions are frequently deformed, subject to growth cracks and not attractively colored. Indifferent results may also be expected on light, shifting sands.

Acidity of soils. Caution should be taken in the addition of sulfur to potato soils with the objective of lowering the pH (increasing the acidity) to control scab. Normal fertilizer practices, such as the continued use of ammonium sulfate, so increase soil acidity that the addition of sulfur may be more detrimental than helpful.

Although the potato plant will grow in quite acid soils, there seems to be general agreement that the best yields will be secured with a soil pH of between 6.0 and neutral (pH 7) or above. Fair yields, however, can be expected with a pH slightly lower than 6.0. When the pH in the soil is 5.5 or less, nitrification is markedly reduced and much of the ammonium fertilizer will remain in the soil unused. Under these conditions low yields are the result.

Investigators generally agree that some degree of scab control can be obtained by making the soil acid to the extent of a pH 5.5 to 5.3. A pH of 5.5 or below means that the acidity will be high enough to interfere with the normal growth of many plants. If attempt at scab control is made by lowering the pH (increasing the acidity), some reduction in yield will occur. In older potato fields in which the pH of the soil has been reduced by ammonium sulfate, probably no more than 100 or 200 pounds of sulfur per acre should be added at one time. Once the soil becomes badly infested with scab, or the pH is reduced sufficiently for control, a reduction in marketable potatoes will result, either from poor quality or from low yields.

Potato Seed

Every year some growers are disappointed in their yields. They do not grasp the main fact of potato growing: *without the use of good seed, high yields are impossible.*

Quality

Although seed tubers of a certain definite type—smooth, good sized, and attractive in appearance—are often selected, none of these factors has any consistent correlation with producing qualities. The appearance and shape of tubers depends chiefly on the soil and climate of the locality where they were grown. Naturally, tubers are preferred that are free of knobby second growths, rots, and tuber-borne diseases. Because the buying public will never understand that misshapen or undersized tubers (*if from healthy plants*) may be perfectly satisfactory as seed stock, it is usually unwise to offer them for sale. Conversely, tubers of ideal size, type and symmetry may be infected with virus disease not detectable until they produce plants.

As a result of the seed-potato certification agencies that have been established in practically all of the states producing seed, it is possible for those who desire to plant good seed to procure it either through the seed-certification agencies or from individuals whose seed has been certified.

Storage conditions have considerable effect on the quality of seed. Potatoes kept in a warm place and allowed to develop long sprouts before planting are usually unable to produce good stands of uniformly vigorous plants. When cold storage is used a temperature of 36° to 49° F is most favorable. Good ventilation is necessary to carry off surplus moisture. This tends to reduce both decay and sprouting of potatoes. The work of Smith (1937) may be consulted for a critical

treatment of storage factors affecting seed value.

There is little evidence that irrigation, or that soil and air temperature conditions alone, under which seed potatoes are grown, affect their yielding ability.

Certification

Certification of California potatoes grown for seed purposes is administered by the California State Department of Agriculture. High quality seed stock can be produced in several districts of the state, and constantly increasing interest is being taken in certified seed by the seed growers and their customers.

The grower of certified seed must comply with the standards and regulations governing certified seed production, particularly the isolation of seed fields from table stock. He must always be on the alert for varietal mixtures and diseases.

The extent of spread of virus diseases in interior California varies consistently with the time of planting. In general, aphids, which carry virus diseases, are prevalent during April, May, and June. With the advent of high temperatures during the summer months, aphid prevalence and activity decrease significantly. Many growers now plant their seed fields between July 1 and August 1, and their experience has demonstrated that virus spread in such late planted stock is relatively insignificant.

Much of the California potato acreage is planted with seed grown in other states, particularly Minnesota, Wisconsin, Oregon, Idaho, Montana, and Washington. In each of these states, potato-seed certification is practiced, and usually high quality seed may be obtained if the California grower specifies he will accept only seed which has passed inspection and has been certified by the proper authorities.

Certified seed is in no sense resistant to disease, and seed dealers and potato growers should not expect that certification guarantees a profitable crop.

Dormancy and How to Shorten It

It is well known that potato tubers require a rest period after digging before they will sprout readily. The rest period varies greatly between varieties, some requiring a much longer rest period than others. The problem of dormancy is in general not of importance in growing the spring and summer crop since most of the seed has been in storage for some time and seedpieces sprout readily after planting. However, a considerable quantity of seed harvested in June and early July is used in planting a fall crop in late July or August. Each year numerous questions are received from growers desiring information on methods of shortening the rest period of seed potatoes.

In general, dormancy may be shortened in varying degrees by mechanical, physical, and chemical means. Anything that upsets the normal rest period will shorten dormancy. Mechanical means would be cutting or bruising the seed potatoes. A physical method of shortening dormancy is to subject tubers to extremes of temperature, either high or low, or to give them a cold shock immediately followed by rapidly rising temperatures.

Experiments in shortening the dormant period of White Rose variety indicate that the most effective storage period and temperature is 1 month to 6 weeks at a temperature of 70° F. If potatoes have been harvested for as long as 6 weeks ahead of the desired planting date, it is recommended that they be stored at 70° F and planted without chemical treatment.

More than 200 different chemicals have been tested experimentally in attempts to produce prompt sprouting of dormant tubers without causing injury to the eyes. The chemical treatment which has proved most successful under California conditions is ethylene chlorhydrin.

Ethylene chlorhydrin is a liquid, which is sold by the pound either in a pure form

or in a 40 per cent solution. It may be used either as a dip on cut seedpieces or as a gas on whole or uncut potatoes. The gas treatment is more widely used.

Dipping cut seedpieces. Prepare a 1.2 per cent solution of pure ethylene chlorhydrin (by volume) in water. Dip the seedpieces and place them immediately in an airtight enclosure for 16 to 24 hours. Then remove and plant.

Gassing whole or uncut potatoes. Any method which employs ethylene chlorhydrin as a gas requires that unusual precautions be taken to protect the operator from fumes.

A system which can be used with comparative safety makes use of an airtight treatment room. An atomizer, such as a paint spray gun, is mounted on the ceiling in the center of the room. Liquid ethylene chlorhydrin is conveyed to the gun by compressed air from pressure tanks on the outside of the room, and is atomized into the atmosphere in the room.

The only exposure to the operator using this system will be when he enters the chamber to obtain samples. Oxygen-breathing apparatus should be worn at such times, since amount of oxygen in the room will be reduced as well as the poisonous ethylene chlorhydrin fumes being present.

Mechanical ventilation of the treatment chamber is absolutely necessary, and the minimum quantity of ventilation necessary is about 500 air changes.

Treating small lots. For treating small lots of seed potatoes, use 22 grams of pure ethylene chlorhydrin per 100 pounds of potatoes. This is the equivalent of 1 pound or 0.40 quart of pure liquid per ton of potatoes. Place the ethylene chlorhydrin in a shallow container above the potatoes, or wet sacks or other cloth with the liquid and hang on wires above the potatoes. The gas from the solution is heavier than air and will settle toward the floor. The potatoes must be gassed in airtight containers or rooms for 3 days. Then open and allow to aerate before cutting and planting. If the 40 per cent solution is used in place of pure ethylene chlorhydrin, use 2½ times the quantities given above.

Ethylene chlorhydrin should be used with extreme caution—the fumes are toxic if inhaled for prolonged periods. The solution is also absorbed directly through the skin.

Cutting Seed

There is no satisfactory substitute for careful hand cutting of seed potatoes. However, several mechanical devices for cutting seed potatoes have been designed and patented from time to time, particularly within the past few years, with the objective of keeping the cutting surfaces sterilized to prevent the spread of bacterial ring rot. Some are for power and some for hand operation. Among these are the Colorado rotary potato cutter and the double-edged stationary potato-cutting knife.

While mechanical cutters reduce the time element to a minimum, they are nevertheless mechanical and a small percentage of no-eye seedpieces may be expected.

Many different types of cutting bins, knife arrangements, systems of supplying seed to cutters and removing the cut seed, have been devised with the idea of increasing individual cutting efficiency. The choice should be left to the individual grower.

Seedpiece Size

Many comparisons have been made on the relative value of cut seedpieces versus whole seed, and on the best seedpiece size. Whole seed potatoes, usually called "drop seed" or "single seed" (from 1 to 2 ounces in weight), may be safely used if they come from healthy plants. There is danger in selecting small tubers from the bin unless all the plants in the field where the crop was grown are relatively free from virus disease; otherwise the possibility remains that many of the small

tubers came from diseased plants and will produce diseased progeny. Disadvantages of whole seed are the difficulty of planting with a machine, the danger of disease perpetuation, the slowness of germination if the seed is immature, and the excessive number of sprouts produced if the seed has been in storage for a long time. The point should be emphasized that small potatoes, 1 ounce or over, need not be discriminated against if the stock is from disease-free fields.

Numerous tests have been conducted to determine the proper size of the cut seedpiece, and several conflicting opinions are held. It has been found that small seedpieces produce fewer sprouts and fewer but larger potatoes; on the other hand, large seedpieces produce more sprouts and more but smaller potatoes. The size of the seedpiece to be used depends on fertility of the soil, distance between rows, and distance between the seedpieces in the row. A seedpiece which weighs 1½ to 2 ounces is probably the best average size.

Care of Cut Seed

Seed potatoes may be cut and planted immediately, or they may be cut in advance of planting if proper conditions are provided to facilitate the suberization, or corking over, of the cut surface. At a temperature of from 60° to 70° F, with an atmospheric humidity of 85 per cent, the formation of cork cells or periderm tissues seems to progress most rapidly. Exposure for 10 days to such conditions seems to be sufficient to insure good suberization, after which cut seed may be held for several weeks at a temperature of 36° to 40° F if desired.

The ideal method of handling is to cut the seed and plant immediately. If the seed is to be planted at once after cutting, the pieces are apt to stick together and its handling in the planter may be facilitated by dusting with some absorbent such as land plaster, slaked lime, gypsum or cement. Put a cupful of the absorbent in the sack and shake well before emptying seed pieces into the planter.

Seed Treatment

There is a tendency on the part of some growers to neglect seed treatment, particularly if the seed has a clean external appearance. Nevertheless it is considered advisable to treat all potato stock, cut seed and whole seed, before planting. Rhizoctonia and common scab as well as other disease-producing microörganisms may be lodged on the surface without being visible to the naked eye.

Seed treatment will kill only the disease germs carried on the seed itself. When potatoes are planted in infested land, infection of the potato crop from the soil cannot be prevented by any treatment of the seed. The principal benefit derived from seed treatment is to prevent infesting the soil with disease-producing organisms and to control infection from the seed in the new crop. Several different treatments for seed potatoes are in use, no one of which can be considered best under all circumstances. Choice of the treatment is up to the grower, and will depend largely on the facilities he has available.

1. ***Corrosive sublimate*** (mercuric chloride). Corrosive sublimate is dissolved in water at the rate of 1 ounce in 8 gallons. The necessary quantity can be dissolved in a gallon of warm water and later diluted to the proper strength. *Use wooden, crockery, or concrete container.* Soak the seed potatoes in this solution for 1½ hours. Both rhizoctonia and scab are controlled by this treatment. The solution gradually weakens and should be reinforced, after 4 lots of potatoes have been dipped, by adding ½ ounce of corrosive sublimate for each 8 gallons of water in the original solution. The solution should also be brought up to its original volume. After dipping 8 lots of seed, the solution should be discarded and a fresh one prepared.

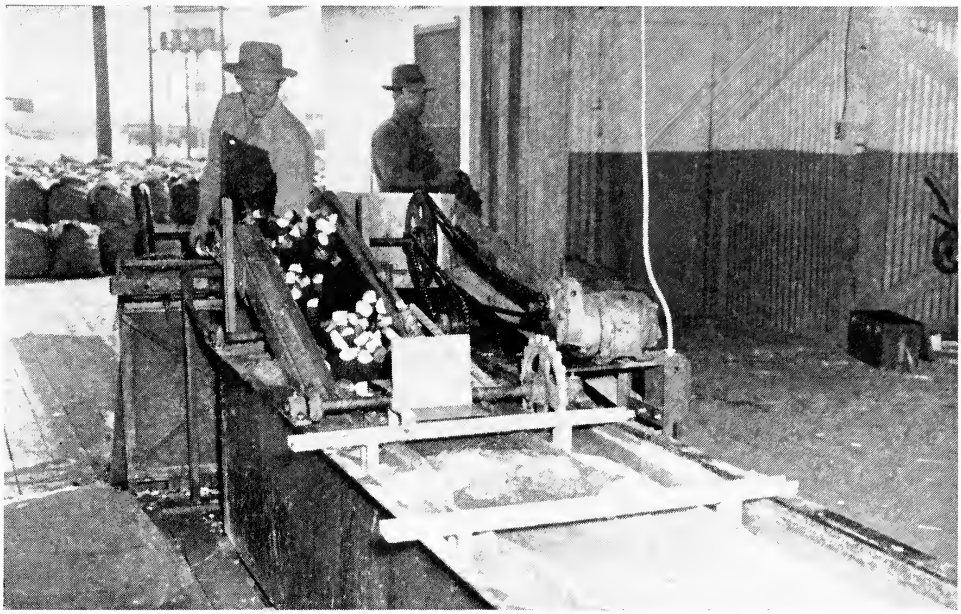


Fig. 2. Treating cut potato seedpieces with a fungicide.

Caution.—Corrosive sublimate is a deadly poison and extreme care should be exercised in its use. Corrosive sublimate solutions are very corrosive to metal and should be used only in wooden, crockery or concrete containers. Potatoes treated with corrosive sublimate should not be used for food. Care should be exercised in the disposal of the solution after treatment.

2. ***Hot corrosive sublimate.*** Use the same strength solution as in No. 1, bring it to a temperature of 126° F and soak the seed in it for exactly 2 minutes. This is a very powerful solution and directions should be followed explicitly.

3. ***Acidulated corrosive sublimate.*** Soak the seed potatoes for 5 minutes in a solution composed of 6 ounces of corrosive sublimate, 1 quart of commercial hydrochloric (muriatic) acid (31 per cent acid), and 25 gallons of water. This treatment requires no temperature control and is very effective against scab and rhizoctonia. Potatoes should not be left in the solution to exceed 5 minutes lest damage to the eyes results.

4. ***Hot formaldehyde.*** Hot formaldehyde does not have many of the disadvantages of corrosive sublimate. It does not lose strength during continued use, it may be used in metal containers, it is not highly poisonous, and tubers treated with it may be used as food.

Hot formaldehyde is used as follows: Add commercial formaldehyde (37 to 40 per cent solution) to water at the rate of 1 pint to 15 gallons. Heat to 124° to 126° F and dip the tubers (in sacks) for 3 to 4 minutes. Time and temperature controls should be quite accurate. The solution may be heated by means of an open fire, steam coils, or gas burners. Commercial machines for treating potatoes by this method are on the market.

5. ***Proprietary organic mercury compounds.*** Several different compounds of this nature are on the market. Among the best known of these materials are Ceresan, New Improved Ceresan, Semesan (several types), and Merko. Manufacturer's directions should be followed.

Cultural Methods

Preparing the Soil

Proper preparation of the land includes deep plowing and thorough pulverization of the soil prior to planting the crop. It is impossible to produce maximum yields of well-shaped tubers from poorly prepared soil.

Whether plowing should be done in the fall or in the spring is largely determined by the physical character of the soil, its exposure and the previous crop grown. Heavier soils are benefited by fall plowing and exposure to the action of winter weather and rains. If manure or cover crops are to be turned under, plowing should come early enough for the material to rot thoroughly before planting time. Fall-plowed land may be quickly fitted for planting by one or two thorough diskings.

Planting

The date of planting depends on the district where the crop is grown, the most profitable season of marketing, and the hazard from frost. It varies from November in the Edison district of Kern County and the Colma district below San Francisco, to July and August in the interior valleys where a late crop is grown. Generally speaking, with the commercial crop, the earlier the planting date without undue risk of frost, the more satisfactory the development of the plants and of the crop, and the less danger of injury from heat and tuber moth. The time of planting, although it affects both the production and the value of the crop, has to be determined largely by local conditions.

Planting is usually by machine, of which several types are available. They may vary in the number of rows planted, from 1 to 4; in the number of operators required, from one to several; and in the

Fig. 3. A four-row picker-type potato planter in operation.

mechanical design such as the assist-feed or picker type. The type of planter selected depends on the preference of the individual grower, his acreage and the help available. Every effort should be made to secure a planter that will give accurate, uniform spacing of the seed.

Rate of planting in California varies from 12 to 20 sacks of seed potatoes per acre, depending on the spacing between rows and between seedpieces in the row, and on the size of the individual seedpieces.

The soil should contain enough moisture at planting time to germinate the seed promptly and to support its development until the sprouts are well above the surface of the soil. Occasionally, the land must be irrigated in preparation for the spring plantings. Irrigation is always necessary before planting the fall crop.

In extensive depth-of-planting tests at Shafter and Davis, Lorenz (1945) concluded that all factors considered—yield, size of tuber, and injury from sunburn—planting the seedpieces at a depth of 4 to 6 inches is more desirable than either more shallow or deeper plantings.

Fertilizing

The potato is an intensively cultivated crop and high yields per acre are desirable. In order to accomplish this end the soil must be maintained in a condition of high fertility.

Soil needs. Experiments in Kern County have shown that one crop of potatoes will remove from 125 to 200 pounds of nitrogen, about 60 pounds of phosphoric acid and about 300 pounds of potash per acre. Few, if any of the soils in California, will produce maximum yields without the addition of varying amounts of plant nutrients in one form or another. The addition to the soil of organic fertilizers and humus such as manure and cover crops, will, as in the case of other crops, prove beneficial. However, potato culture in California has come to depend primarily on the addition of inorganic nutrients or "commercial fertilizers" to the soil.

Extensive fertilizer tests have been conducted with potatoes in Kern, Fresno, San Bernardino, Riverside, Los Angeles, and Lassen counties and in the Cuyama Valley and Tulelake district. The practices which have been found applicable in one locality or on one soil type will not always prove economical when applied in other districts.

In Kern County application of nitrogen has always given responses up to about 100 pounds of nitrogen (which are present in 500 pounds per acre of ammonium sulfate). In the lighter, more heavily irrigated soils or where potatoes are grown throughout the winter, somewhat higher amounts are justified. At Fresno it appears that at least 140 pounds of nitrogen per acre is justified on the spring crop, while half this amount is sufficient for the fall crop. In all tests in the central valley there has been a slight response to phosphorus. The application of a fertilizer containing some phosphorus is recommended.

At Tulelake, in Lassen County, and in the Cuyama Valley, both nitrogen and phosphorus give a response, and a good recommendation in these areas is the application of a fertilizer which will supply 80 pounds each of nitrogen and phosphoric acid per acre. On the peat lands of the Delta region, it is a common practice to apply 500 to 1,000 pounds per acre of a 10:10:10 fertilizer on the older fields, while on new or burned-over peat land less nitrogen is needed, so about the same application of an 0:10:10 fertilizer is used. Fertilizer recommendations for the different potato-growing areas, based on existing experimental evidence, are summarized in table 4.

What to use. Experiments to determine the best source of nitrogen have shown that ammonium sulfate alone has consistently given the highest yields. Organics, such as dried blood used alone or half and half with ammonium sulfate,

Table 4. SUMMARY OF FERTILIZER RECOMMENDATIONS FOR THE PRINCIPAL POTATO PRODUCTION AREAS OF CALIFORNIA

Area	Fertilizer	
	Parts of Nitrogen : Phosphorus : Potassium	Rate of application, pounds per acre
Upper San Joaquin Valley	20–0–0 or 16–20–0 or 17–7–0	600
Riverside–San Bernardino	20–0–0 or 16–20–0 or 17–7–0	600
Tulelake	16–20–0 or 11–48–0	400
Delta	10–10–10 (on older fields)	500 to 1,000
	0–10–10 (new or burned-over land)	500 to 1,000
Miscellaneous mountain areas	16–20–0	600
Miscellaneous coastal areas	20–0–0	600

have not given better results than straight ammonium sulfate. Nitrate of soda and calcium nitrate gave but little better results than no fertilizer, and ammonium nitrate seems of benefit only for the ammonium that it contains. Uramon in some cases is as beneficial as ammonium sulfate but in other cases is inferior. If placed too close to the seedpiece, uramon may reduce germination. Cyanamide has proved toxic, as little as 50 pounds of nitrogen per acre from this chemical showing toxicity throughout the entire growing season.

Fertilizer should be applied at the time of planting the seedpieces. The method of application may vary somewhat but the most satisfactory and probably most universally used is by means of an adjustable fertilizer attachment carried on the planter. The fertilizer should be applied in a band about one inch below and two inches to the side of the seedpiece.

Cultivating

The chief purposes of cultivation after potatoes have been planted are to control weeds, prepare the land for the distribution of moisture, and keep the tubers covered to prevent sunburn and reduce potato tuber moth infestation. A thorough study of root development of the potato was made in Nebraska by Weaver. He found that while potato roots penetrate into the third and fourth foot of soil, the majority are found in the top foot or eighteen inches. This indicates the advisability of rather shallow cultivation after the plants are well established. Cultivation should be reduced to a minimum that will accomplish the desired results. It should be kept as far away from the rows as possible. Where potatoes are grown on ridges or beds, cultivation should be completed early in the life of the plant and the soil left undisturbed thereafter. Root pruning by cultivation will not force the roots to go deeper. If the roots near the soil surface are injured, the most efficient utilization of available nutrients will not be realized and reduced yields may be expected.

Irrigating

Almost every conceivable irrigation practice is followed in the various districts of California. The methods include culture under winter rainfall conditions at Colma, dry-farming summer culture in Marin County, irrigation on alternate days in the Shafter-Wasco district, and almost continuous subirrigation in the Delta area. Overhead irrigation is practiced to some extent in certain sections, particularly in San Diego County.

Tubers begin to form when the plants

are 5 or 6 inches tall and are completed by the time the flower buds are formed. Conditions during this period determine the number of tubers set. From the beginning period until the plants begin to mature, the tubers should grow at a regular rate. If the soil becomes too dry, normal tuber development is retarded, the skin of the tuber "sets" and subsequent irrigations may be responsible for growth cracks, rapid expansion in the region of eyes and knobby second growth.

Although the potato is a shallow-rooted plant, a few roots penetrate deeply, but they are not numerous enough to permeate the soil thoroughly at greater depths. It is necessary to keep available soil moisture in the surface foot of the soil if best results are to be obtained. A total application of 30 inches of irrigation water for the production of the early potato crop, and 20 inches for the late crop, is recommended.

Harvesting

The yield of marketable potatoes increases rapidly as the plants approach maturity, even increasing somewhat after the vines have turned yellow. Because early potatoes often bring high prices, a considerable portion of the crop in the Colma district, and the spring crop in central and southern California, are harvested before fully mature. Early potatoes in most of the other areas of the state, and all the late potatoes, are allowed to reach maturity or to grow until the vines are killed by frost.

The skin on immature potatoes is very thin and is easily rubbed off. As the potatoes approach maturity, the skin becomes thicker, tougher, and more firmly attached to the tuber. The advancement of this change in the coat of the tuber is important in determining when to start digging early potatoes. If harvested too immaturely, some of the skin may be injured

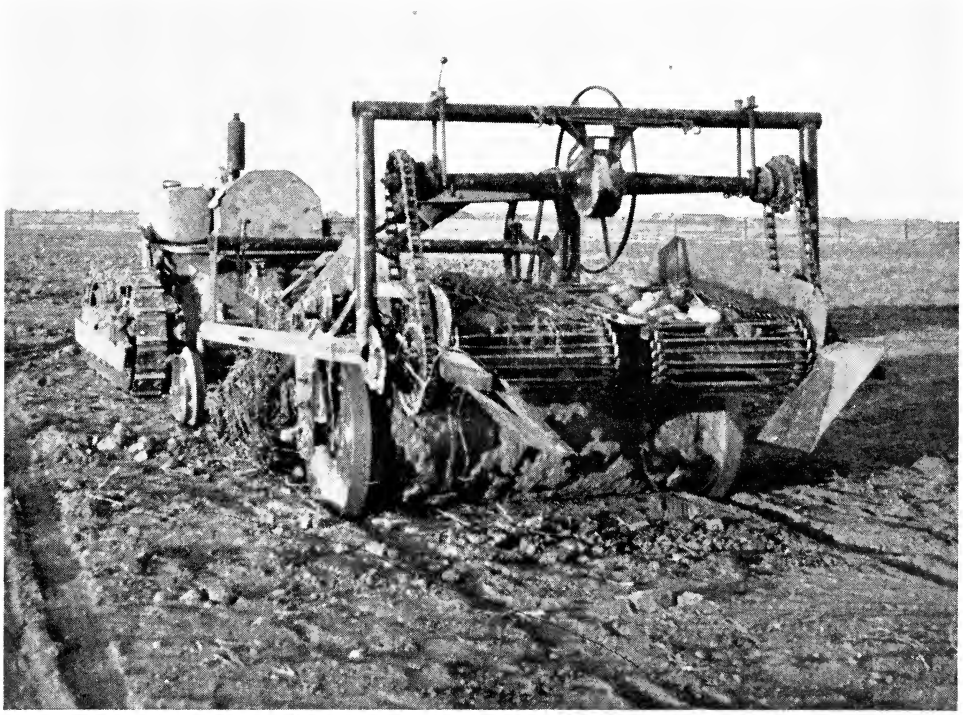


Fig. 4. A two-row potato digger. Note the roller instead of rear wheels.

during digging, grading, sacking or loading operations. Such skinned areas quickly darken and often are the starting places for decay.

Potatoes are dug by machine, generally of the one- or two-row type. Most diggers are now equipped with a roller extending the width of the machine to replace the pair of rear wheels formerly used. The roller breaks down the clods and smooths out the soil disturbed by the plow end of the digger. The result is a smooth somewhat compact surface upon which the potatoes are dropped. This greatly facilitates picking up.

After digging, the potatoes are picked from the ground into sacks by hand. Workers are paid for this operation on a piece-work basis, generally so much per "half sack."

Handling and shipping tests have shown that as quickly as possible following digging, the potatoes should be picked up and hauled to the packing sheds. Tight-meshed picking sacks should be used, and they should be protected from sun and wind en route from field to shed, by a heavy canvas cover to reduce surface browning. Any practice which reduces moisture loss from the surface of the potato also reduces browning. The full extent of the injury from drying of skinned areas is hard to detect at the time of packing, because only severely injured potatoes turn brown in this short time. Browning continues to develop during shipment to market.

Grading

At the packing shed, the potatoes are first put through machines equipped with revolving brushes and water sprays. The potatoes then move on a divided belt conveyer past graders who sort the stock so that finally each division of the belt contains but a single grade. The tubers drop from the end of the grading belt into sacks, usually of 100 pounds. Operators check, weigh, and sew the sacks and truck them into the cars for shipment.

Storing

A relatively small percentage of the potato crop in California is placed in storage. This is in contrast to the procedure in the main late potato-producing states. In California much of the table stock is matured during extremely hot weather and is rapidly placed on the market. The early crop is frequently harvested from April to July when immature.

A portion of the late crop, harvested from October to December, is stored. This crop is produced mainly in the Tulelake area, in the San Joaquin Valley, in certain coastal districts, and in Riverside County. Winter temperatures in these districts, except Tulelake, rarely fall below freezing, and growers often have difficulty in maintaining the necessary low storage temperatures unless they resort to cold storage—a rather expensive item for table stock. Such difficulty is not experienced in the Tulelake district, where the winter temperature often is well below freezing.

The quantity of seed potatoes for storage has increased considerably during the past few years. Seed stock is produced in many districts and requires different storage methods. The seed crop is stored both in bulk and in sacks, with increasing quantities being held under artificially maintained low temperatures. The length of storage period for seed stocks varies with the season of production and the district in which the seed is sold for planting.

Studies of the effect of storage on potatoes for both seed and table use have shown that varieties often respond differently under identical storage conditions. (Wright, *et. al.*, 1936.)

Temperature. Cooking quality, palatability and composition are markedly influenced by storage temperature, whether the potatoes are used for boiling, baking, French frying, steaming, or chip making. In general, storage temperatures at or below 40° F result in an increase in unpleasant sweetness, in a change from a fluffy and white consistency to one that is soggy and slightly yellow. If tubers are

stored for six to eight weeks at 40° F and the temperature is then raised to 70° F for three or four weeks, they recover their original quality. It is recommended that table stock be stored at or near 50° F with adequate ventilation to prevent the occurrence of blackheart.

Sprouting of table stock can be held back for long periods of time by treating with the methyl ester of alpha-naphthaleneacetic acid applied in Pyrax Talc dust, or by using impregnated shredded paper. Both of these are commercial products. The dust may be shaken in the sacks or over and around the sacks. The shredded paper is thrown loosely around the sacks.

For seed stock the most satisfactory storage conditions are obtained at approximately 40° F with sufficient ventilation to ensure adequate oxygen and to prevent blackheart. If the storage period is relatively short, the temperature might be raised to 50° F. The danger of the higher temperature is that excessive sprouting may result if the storage period is prolonged.

Potatoes May Have Serious Diseases

Because of the dry summer climate and low humidity in the interior valleys, the California potato crop is not subjected to some of the defoliation diseases which are serious in areas experiencing summer rainfall. The most serious potato diseases in California are scab, rhizoctonia, and virus diseases.

Scab

Round, brown, rough areas are seen on the surface of the tuber. These areas may be few or numerous enough to cover the entire surface. The fungus causing this scab thrives under high temperatures and in alkaline or very slightly acid soil.

To control scab use clean seed, disinfect seed thoroughly, and plant in clean soil. Methods of seed treatment are given on page 12. Crop rotation should be practiced when no new potato lands are available. When planting new land, treat all seed very carefully, even though it may not show scab. This will help prevent infestation of the soil.

The practice of adding sulfur to soils to increase their acidity and thereby discourage scab disease is one to be followed with caution. Yield decreases where soil is more than mildly acid. (See page 9.)

Rhizoctonia disease

A fungus disease causing small, black particles of fungus tissue up to 1/3 inch in diameter on the potato. Presence of the disease is indicated by the leaves, which tend to roll upward and may turn yellow. Small aerial tubers may develop in the axils of the leaves on severely affected plants. Young sprouts in the soil are rotted or burned off below the surface. The roots may be corroded by the fungus.

Crop rotation and seed treatment are the principal methods of keeping this disease under control.

Virus diseases

At least ten virus diseases of potatoes have been recognized in California. They cause the foliage to be more or less mottled, dwarfed, crinkled and distorted, and the vigor and yield of the plants to be reduced. These diseases are transmitted in the seed potatoes, and are spread from plant to plant by aphids and other insects.

No one can tell by looking at potatoes whether or not they are affected with virus diseases. Inspection of the growing plants is necessary for identification. Virus diseases are controlled by planting seed which is free from the disease.

Most Injurious Pests of Potato

Assistance in the preparation of this section was received from A. E. Michelbacher, M. W. Allen, and E. S. Sylvester, of the Division of Entomology and Parasitology.

Potato Tuber Moth

Caterpillars of the potato tuber moth burrow through the tubers as long as they are available, either in the field or in storage. The full-grown caterpillars are white or pinkish and not over ¾ inch long.

Pupation occurs in white silken cocoons on the plant, in the surface soil, in sacks or storage bins. The adult moths are small and gray with silvery bodies and minute dark specks on the forewings. Each female may lay from 150 to 200 oval, pearly white eggs, any place on the potato plant or in storage.

To prevent infestation of the potatoes in the field, hill up well around the growing plants, remove the potatoes from the ground as soon as dug, and destroy all volunteer potato plants. Packinghouse sanitation should be practiced. Plant only clean seed.

Potato Flea Beetle

These tiny, flealike beetles are shiny black or brown. They perforate the leaves of the plant early in the spring. Their larvae burrow into or feed on the tubers, causing pimply potatoes. Early-planted potatoes are damaged most, and small fields are damaged more than large plantings.

The only practical control is directed against the adults. If infestation warrants, dust with 5% DDT.

Wireworms

Wireworms have smooth, round, shiny bodies, varying from pale yellow to dark brown. They are about 1 inch long. They live in the soil and the larval stage may last from one to three years. The adults are called click beetles because when placed on their backs they jump into the air with a clicking sound.

Control measures are extremely difficult. Clean culture and crop rotation are practical measures on large acreages. To fumigate the soil with ethylene dibromide before planting is an effective control, although somewhat expensive.

Fig. 5. Above, work of the potato tuber moth. Below, injury by the potato flea beetle.

Potato Aphid

Large uniform green or pinkish aphids infest the young shoots and terminal growth of the potato plants. They are sucking insects and in their feeding they carry virus diseases from plant to plant.

The green peach aphid, a most troublesome species in much of the potato-growing area, can be controlled by applications of DDT dust. These should be applied at intervals of 7 to 10 days during the season of infestation, beginning when plants are four to six inches high.

The organic phosphate parathion would give excellent control when applied as a dust, but the hazards of applying this material must be considered. It is extremely toxic to animals, including man.

Potato Psyllid

This insect sucks the cell sap from the leaves, and injects a toxic substance into the plant which causes the condition known as "psyllid yellows." The plant becomes stunted, the leaves curl and turn yellow, and the condition results in poor development of the tubers.

Damage is caused by the immature forms, or nymphs, which are yellowish orange to green in color, and flat and elliptical in shape. The nymphs secrete quantities of white wax.

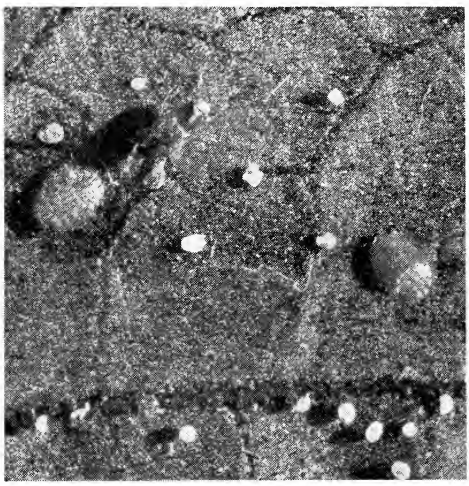
Best control is obtained by dusting thoroughly with sulfur.

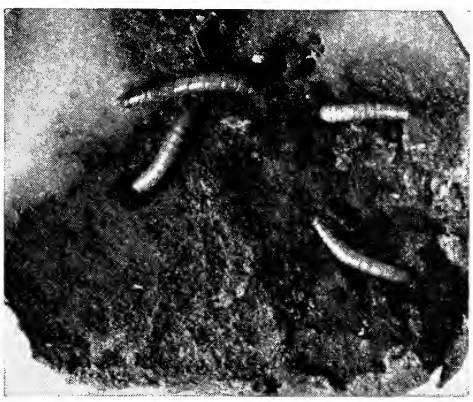
Root-Knot Nematode

Root-knot nematode is rarely a problem of early potatoes in California. The late commercial crop is sometimes damaged, and in some areas seed potatoes are subject to injury.

Nematode injury gives the potato a warty, rough appearance outside. Inside, the tubers have scattered black spots about ¼ inch below the surface. The nematode is contained in these black spots.

Two cultural practices, crop rotation and summer fallow, should be followed in controlling nematodes. Chemical control measures are possible with fumigation,





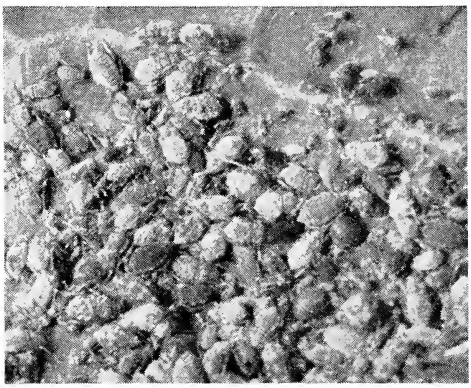


Fig. 6. Left, potato psyllid nymphs and white dots of excrement. Below left, wireworms live in the soil and bore into potato tubers. Right, potato aphids carry virus diseases as they feed.

but the grower should carefully consider the cost to determine if such control is feasible.

Crop rotation involves rotating potatoes with some less-susceptible crop on the same land. The grains, particularly oats and barley, are most satisfactory.

Summer fallow allows the soil to lie fallow for a period in the summer, during which it is worked two or three times to dry it out thoroughly. Drying the soil tends to kill out the nematodes. This practice works best in lighter, sandy soils.

There are three chemicals on the market at present which give satisfactory results as fumigants. Shell D-D or Dowfume-N, containing the active ingredient, 1,3–dichloropropene, are used at the rate of 20 to 25 gallons per acre. Dowfume-W 40, in which the active ingredient is ethylene dibromide, is used at the rate of 20 gallons per acre. The total cost of treatment with these chemicals, for material and application, is about $40 an acre. Planting of the land should not take place for two weeks after application of the chemical. The fumigants are most effective on light soils.

In order that the information in our publications may be more intelligible it is sometimes necessary to use trade names of products or equipment rather than complicated descriptive or chemical identifications. In so doing it is unavoidable in some cases that similar products which are on the market under other trade names may not be cited. No endorsement of named products is intended, nor is criticism implied of similar products which are not mentioned.

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C. W. Rubel, Acting Director, California Agricultural Extension Service.

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